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PINUS

(pines)

Pines (*Pinus*), the most important conifers, grow around the world in the Northern Hemisphere. Southward they occur as far as Nicaragua, northern Africa, Asia Minor, and Malaya. One species crosses the Equator in Sumatra. Thirty-six of the 90 to 100 species in the world are native in the United States.

Pine trees usually have furrowed bark, resinous wood, and an upright axis which produces each year a long shoot with one or more circles (whorls) of spreading branches. Buds are large, pointed, usually resinous. The needlelike leaves are borne in clusters or bundles of mostly 2 to 5 (rarely more or only 1). They persist from 2 to 12 years in different species.

Numerous male strobili are clustered at the base of current year's growth in lower part of crown. Ovulate strobili are borne on the same tree, especially in upper part of crown, sometimes clustered near the end of the current year's growth. The woody cones may be egg-shaped or cylindrical but are sometimes oblique and not symmetrical. They mature at the end of the second year (rarely third) and may shed promptly or remain attached to the tree, sometimes not opening. Seeds are long-winged or sometimes wingless. Cotyledons 4 to 15.

Pines are separated into two groups. The soft or white pines (subgenus *Haploxylon*), have mostly soft wood and needles commonly in clusters of 5, with 1 vascular bundle in cross section. The hard pines (subgenus *Pinus* or *Diploxylon*) have mostly hard wood and needles commonly in clusters of 2 or 3, with 2 vascular bundles in cross section.

F—490470

WESTERN WHITE PINE (*Pinus monticola* Dougl.)

Other common names: Idaho white pine, white pine, silver pine, and mountain Weymouth pine.

Western white pine grows along west coast mountain ranges from Vancouver Island and the Homathko River on the adjacent mainland in British Columbia southward to the Southern Sierra Nevada Mountains of California. In the interior its range is from Quesnel Lake through the Selkirk Mountains of British Columbia southward into Northern Idaho, western Montana, and northeastern Washington and also into the Blue Mountains of southeastern Washington and northeastern Oregon. The species attains its greatest size and reaches its best stand and commercial development in northern Idaho and adjacent sections of Montana, Washington, and British Columbia (*2*, *43*).[1]

HABITAT CONDITIONS

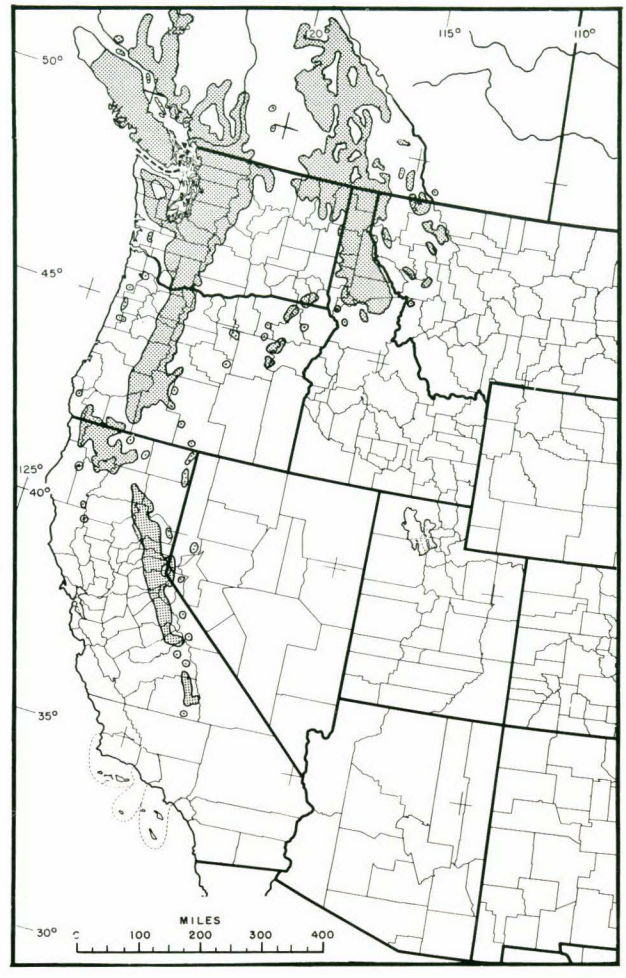
Climate

Western white pine is restricted to the Pacific Coast type of climate and the eastward extension of that type, the sub-Pacific type, into the northern Rocky Mountains. These climatic types are marked by a predominance of winter precipitation (*15*).

In the region of most abundant occurrence of western white pine, the Inland Empire, which includes northern Idaho and adjacent parts of eastern Washington, western Montana, and southern British Columbia, the climate is characterized by a short summer season of scanty precipitation and low humidities with a high percentage of clear, warm, sunny days, and winters with heavy snowfall and fairly low temperatures (*36*).

Annual precipitation ranges from 28 to 60 inches, and is distributed seasonally as follows: 35 percent, winter; 24 percent, spring; 14 percent, summer; and 27 percent, fall. Growing season (May through August) precipitation varies from 5 to somewhat more than 7 inches. Snowfall averages 103 inches but ranges from 48 to 244 inches.

Average annual temperatures range from 40° to 50° F. Average July temperatures vary from 62° to 72°. Extremes in temperature range from a low of −36° to a high of 107°. Average growing season temperatures range from 57° to 66°. Average length of the frost-free season is very short; it ranges from 60 to 160 days, and is very irregular from year to year and from place to place.



F–506624

The range of western white pine.

White pine grows over a very broad range of climate on Vancouver Island. It is found on the west coast of this island in localities where the annual precipitation is 110 inches and the frost-free period is 227 days. It also grows at 5,000 feet elevation, where the frost-free period probably is less than 100 days.[2]

The western white pine type in the Inland Empire appears to be limited at the lower elevations by deficient moisture and at the upper elevations by a summer heat deficiency (*14*, *20*, *47*). The environmental factors that determine upper and lower limits probably operate through control

[1] Italic numbers in parentheses refer to Literature Cited, p. 484.

[2] Communication from R. L. Schmidt, British Columbia Forest Service.

over germination and survival (*19*). The southern boundary of the type in the Inland Empire is not fixed by insufficient precipitation alone but by the balance of precipitation and evaporation (*36*).

Soils and Topography

Western white pine grows on a great variety of soils with little growth superiority on soils of any particular parent material. In the Inland Empire it is found on shallow to deep soils whose surface layers are composed of loess or loessial-like material. Underlying the surface layers, the soil profile is derived from decomposed granite, schist, quartzite, argillite, sandstones, shales, often very rocky in character, decomposed basalt, glacial deposits, alluvial and lacustrine deposits (*25*).

The origin or kind of soil may not be critically important to the growth of western white pine, but the amount of available soil moisture is of utmost importance. Growth of western white pine is best on deep, well-drained, medium- to fine-textured soils of high water-holding capacity (*12*, *13*). In western Washington white pine is reported to outgrow Douglas-fir and western hemlock where soils are poor and unfavorable to these species (*1*).

Soils of the Inland Empire on which white pine grows are slightly to moderately acid; the range of pH is from about 4.3 to 7.0 (*17*). Moisture equivalents in the surface 4 inches of these soils have been found to vary between 18 and 63 percent, and at the 16- to 20-inch layer, from 7 to 40 percent (*17*). Moisture at the wilting point in white pine soils varies from 1 percent in extremely coarse-textured soils to 20 percent in fine-textured soils, particularly those that contain considerable organic matter.

Nitrogen content of the upper A horizon of white pine soils in the Inland Empire has been found to be about normal when compared with similar forest soils, but the organic carbon content is below normal (*24*).

In one study (*63*) annual litter fall for western white pine, ovendry weight, was 1,205 pounds per acre. Foliage nutrient content for this species, as a percentage of ovendry weight, was nitrogen, 0.76; phosphorus, 0.12; potassium, 0.30; calcium, 0.62; and magnesium, 0.08. Nutrient content of freshly fallen white pine foliage collected in September or October in the northern Rockies was found to be, when expressed as a percentage of ovendry weight, nitrogen, 0.54; phosphorus, 0.07; potassium, 0.22; and calcium, 0.74 (*18*).

Western white pine grows in characteristically mountainous country. In the northern extremity of its range on the British Columbia coast, white pine is found from sea level to elevations seldom exceeding 2,500 feet. On Vancouver Island, white pine is frequently found as high as 4,000 feet and occasionally has been found at 5,000 feet.[3] In the northern Cascades of Washington, white pine grows from near sea level on Puget Sound up to about 3,000 feet; farther south on the west side it grows from 2,000 to 6,000 feet, and on the east side, from 1,150 to 4,700 feet. In the Olympics, white pine is found from near sea level up to 1,800 feet. In western Oregon, white pine grows on both sides of the Cascades from 3,000 to 6,000 feet in the north and 5,000 to 7,500 feet in the south. White pine occurs in coast ranges on Iron Mountain and Rusty Butte. In the northern Sierra of California this species generally grows at 6,000 to 7,500 feet. In southern California on the San Bernardino Mountains it is found at 10,000 feet, in the San Jacinto Mountains at 8,900 to 9,500 feet, and on Tahquitz Peak at 8,600 feet. At its northern limit in the interior of British Columbia white pine seldom grows above 3,500 feet, but farther southward in British Columbia it is found at 1,100 to 4,500 feet.

In northern Idaho and contiguous parts of Washington, Montana, and British Columbia, western white pine usually grows between 2,000 and 6,000 feet. Here the topography usually is steep and broken, and white pine occurs largely in irregular, often attenuated bodies following the more moist creek bottoms, lower benches and flats, and northerly slopes. The more extensive bodies of western white pine and the best stands are found in the wide river bottoms, less steep lower slopes, and in the more gently rolling country of the Priest, Coeur d'Alene, St. Joe, and Clearwater River basins.

Associated Trees and Shrubs

Western white pine grows predominantly in the Canadian life zone and also extends into the Hudsonian zone (*56*). It is a seral species in the Engelmann spruce—subalpine fir and the western redcedar— western hemlock vegetation zones (*17*).

Western white pine is represented in 17 forest cover types of western North America. It is a key indicator species in only one cover type, Western White Pine (Type 215). In this type it may make up but a small part of the stand, sharing composition with such tree species as western larch, Douglas-fir, grand fir, western hemlock, western redcedar, Engelmann spruce, lodgepole pine, ponderosa pine, subalpine fir, mountain hemlock, quaking aspen, northwestern paper birch, black cottonwood, white-bark pine, and Pacific yew; it occasionally may occur in nearly pure stands. On the average in this type white pine makes up about half the stand by volume (*36*).

[3] Communication from R. L. Schmidt, British Columbia Forest Service.

F–314095

Western white pine in northern Idaho, with understory of western hemlock.

In the 16 other cover types in which western white pine grows, always as a successional species, it is present either singly or in small groups. Stands in which it predominates are local and rare. These 16 cover types are Engelmann Spruce—Subalpine Fir (Type 206), Red Fir (Type 207), Interior Douglas-Fir (Type 210), Larch— Douglas-Fir (Type 212), Grand Fir—Larch—Douglas-Fir (Type 213), Ponderosa Pine—Larch—Douglas-Fir (Type 214), Lodgepole Pine (Type 218), Western Hemlock (Type 224), Pacific Silver Fir—Hemlock (Type 226), Western Redcedar—Western Hemlock (Type 227), Western Redcedar (Type 228), Pacific Douglas-Fir (Type 229), Douglas-Fir—Western Hemlock (Type 230), Port-Oxford-Cedar—Douglas-Fir (Type 231), Interior Ponderosa Pine (Type 237), and Jeffery Pine (Type 247).

Floristic richness is a characteristic of the forest types in which western white pine grows. The more common associated shrub species in the Inland Empire are (*17*, *40*, *47*, *53*) : Douglas maple (*Acer glabrum* var. *douglasii*), Sitka alder (*Alnus sinuata*), thinleaf alder (*A. tenuifolia*), Saskatoon serviceberry (*Amelanchier alnifolia*), bearberry (*Arctostaphylos uva-ursi*), water birch (*Betula fontinalis*), redstem ceanothus (*Ceaonthus sanguineus*), snowbrush ceanothus (*C. velutinus*), bunchberry dogwood (*Cornus canadensis*), red-osier dogwood (*C. stolonifera*), Oregon wintergreen (*Gualtheria ovatifolia*), creambush rockspirea (*Holodiscus discolor*), western trumpet honeysuckle (*Lonicera ciliosa*), bearberry honeysuckle (*L. involucrata*), Utah honeysuckle (*L. utahensis*), Oregon grape (*Mahonia aquifolium*), creeping mahonia (*M. repens*), rusty menziesia (*Menziesia ferruginea*), American devilsclub (*Oplopanax horridus*), myrtle pachistima (*Pachistima myrsinites*), mallow ninebark (*Physocarpus malvaceus*), whitestem gooseberry (*Ribes inerme*), prickly currant (*R. lacustre*), western black currant (*R. petiolare*), sticky currant (*R. viscosissimum*), baldhip rose (*Rosa gymnocarpa*), Spalding rose (*R. spaldingi*), western red raspberry (*Rubus idaeus aculeatissimus*), western thimbleberry (*R. parviflorus*), Barclay willow (*Salix barclayi*), Bebb willow (*S. bebbiana*), Scouler willow (*S. scouleriana*), Sitka willow (*S. sitchensis*), blueberry elder (*Sambucus cerulea*), blackbead elder (*S. melanocarpa*), Greenes mountain-ash (*Sorbus scopulina*), birchleaf spirea (*Spiraea betulifolia*), subalpine spirea (*S. densiflora*), shinyleaf spirea (*S. lucida*), common snowberry (*Symphoricarpos albus*), big whortleberry (*Vaccinium membranaceum*).

LIFE HISTORY

Reproduction and Early Growth

Flowering and fruiting.—Western white pine flower buds are formed during July and August but are not discernible until the following spring. In northern Idaho staminate strobili—oval, about one-third of an inch long, and borne in clusters of 15 to 25 on branches of the middle crown—are distinguishable about June 1. Here pollen dissemination begins the last week in June and ends about the middle of July. Time of flowering between years may vary as much as 3 weeks and is strongly associated with spring temperatures (*8*). Within individual trees and within localities, maxima of pollen shedding and ovulate flowering practically coincide. No phenological barriers to either selfing or crossing appear to exist (*8*). Most western white pines are self-compatible and self-fertile (*7*). However, under natural pollination, crossing appears to exceed selfing (*61*). Pistillate strobili, greenish yellow to bright pink on stalks at the tips of the upper branches, are first visible about mid-June. The erect conelets are from ½ to 1½ inches long at the time of pollen dissemination, and they grow to 1 to 2 inches by the end of the first growing season. The cones,

nearly all produced in the highest quarter of the crown (*36*), reach mature size, up to 13 inches long (*60*, *71*), in mid-August of the second year. The seeds are ripe from about the end of August to the middle of September.

Seed production and dissemination.—The number of sound seeds per cone is variable. One study (*71*) showed from 6 to 184 seeds per cone with an average of about 90 seeds; another study,[4] from 80 to 220, with an average of about 145; and a third study (*60*), from 2 to 234, with an average of 92. The number of seeds per pound varies from 14,000 to 32,000, with an average of 27,000.

In comparison with its associated species, western white pine bears relatively few cones. A crop of 40 cones is rated good; one of 100 cones per tree is infrequent (*36*). The greatest recorded number of cones observed on one western white pine tree was about 850 on a 55-inch, 400-year-old tree on the Priest River Experimental Forest in northern Idaho.

Cone production of western white pine in the Inland Empire has been observed to begin as early as at 10 years of age (*54*); however, such young trees bear cones infrequently and then only two or three cones per tree. Western white pines at Placerville, Calif., have borne ovulate flowers at 7 years of age (*59*). Cone production increases as trees become older until by the age of 40 years seed production is fairly abundant, and at 70 years of age seed production is both frequent and abundant (*36*). It continues to increase with age until trees are about 20 inches in diameter. After that, seed production appears to have little relation to age or diameter but depends on individual tree vigor and character of crown (*36*) or possibly on heritable capacity to set and bear cones.

Most western white pine seed is borne by vigorous dominant or codominant trees. Good-vigor trees become effective seed producers at diameters of about 14 inches and may bear seven times as many cones as poor-vigor trees, which are ineffective seed producers at any diameter (*36*).

Cones are borne by western white pine at irregular intervals. In stands, complete cone-crop failures are rare; some cones are produced almost every year, but the quantity produced varies markedly from year to year. Good cone crops occur every third to fourth year; however, the productivity of individual areas departs widely from this average (*36*).

Yield of germinable seed in fully stocked stands varies considerably. One study (*71*) in northern Idaho found yields from 16,500 to 184,800 seeds per acre. More extensive studies (*36*) showed average annual yields per acre of about 40,000 seeds in an old overmature stand and 3,500 seeds in a 75-year-old stand.

Amounts of western white pine seed available for regeneration are reduced seriously by insects and small rodents. The cone beetles, *Conophthorus monticolae* and *C. lambertianae*, and cone moths, *Dioryctria abietella* and *Eucosma rescisoriana*, cause serious seed losses in some years (*5*). Western white pine seeds are a favorite food of tree squirrels which cut, gather, and cache the cones. However, squirrel caches are the principal source of cones for collectors of western white pine seed for artificial regeneration.

Seed dissemination begins in late August or early September. About 15 percent of western white pine seed reaches the ground before September 1, and 85 percent by the end of October (*36*).

Wind is the major disseminator of western white pine seed; squirrels, mice, especially the white-footed mouse, and various birds play a very minor role in dissemination. Occasionally mice caches of seed germinate and seedlings come up in dense clumps.

White pine seed usually falls within a short distance from the tree. Records show that seed sufficient to produce adequate reproduction is distributed not farther than 400 feet (*36*). In some instances white pine seed has been disseminated for distances of half a mile or more, but not in quantities sufficient to be relied upon for adequate natural regeneration. Some white pine seed traveled as far as 2,600 feet when released at an elevation of 200 feet in a 13-mile-per-hour wind (*44*).

Seed of western pine is stored naturally in the duff (*36*, *39*). About 40 percent of the seeds are viable after one winter's storage and about 25 percent after two winters' storage. Slightly less than 1 percent retain viability after 3 or 4 years' storage, and only an occasional seed remains viable after 6 years (*36*).

Seedling development.—Seed of western white pine exhibits dormancy (*46*, *65*, *66*) which is normally overcome by stratification at 32° to 40° F. for about 90 days. Western white pine seed normally germinates in the spring in soil wet to field capacity by melting snow. In northern Idaho germination begins in late April or early May on exposed sites but is a month or more later at higher elevations and on protected sites such as north slopes where snow lingers late. It is practically completed by July 1 on exposed sites and by August 15 on protected sites (*36*). Soil temperatures probably control the beginning of germination, and drying out of the topsoil or duff probably stops germination (*36*, *45*). Light appears to have little importance in natural germination of western white pine seed (*36*). Appreciable percentages of western white pine seed stored in the duff germinate in the shade of dense young to

[4] Brewster, D. R. Memorandum and curves on western white pine seed production study. Northern Rocky Mountain Forest and Range Experiment Station. 1916.

F–336547

Excellent western white pine reproduction in a clear-cut strip.

overmature stands (*33*, *35*). Germination is markedly affected by the character of the surface-soil material. Mineral surfaces, burnt or unburnt, are better than duff surfaces (*35*, *36*). Under greenhouse conditions, however, where a favorable degree of moisture was maintained, germination was the same on ash, duff, mineral, and rotten-wood surfaces (*26*).

A high percentage of seedlings dies in the first season. In a study of 15 cutover areas in northern Idaho, 43 percent of white pine seedlings died in the first year after germination, 7 in the second year, 5 in the third, 5 in the fourth, 3 in the fifth, and 2 in the sixth, or a total of 65 percent during the first 6 years after germination. Studies of mortality during the critical first year indicate that early season losses are due principally to biotic agents. Of these, damping-off fungi are the most important but insects, rodents, and birds sometimes cause serious seedling losses (*35*, *36*).

As the season advances and the soil begins to dry, mortality is due principally to temperature and drought. High surface soil temperature is the most important cause of mortality on exposed sites. Temperatures are highest on duff; hence this surface is especially hazardous on the more exposed sites (*35*, *36*).

White pine seedling mortality from drought is most acute on heavily shaded areas where root penetration is slow and unable to keep pace with receding soil moisture (*35*, *36*).

Frost heaving and winter killing also take a heavy toll of young seedlings unprotected by snow cover.

All factors considered, western white pine seedling establishment is favored by partial shade on severe to moderately severe sites. On the more sheltered sites, such as north slopes, light shade to no shade is best for seedling establishment (*36*). Once well established, western white pine grows best in full sunlight on all sites (*36*). Shade of any amount favors its more tolerant associates.

Early root and shoot growth of western white pine seedlings is not very rapid. The primary root grows during the first summer about 6 to 12 inches in open situations, between 5 and 9 inches under partial shade, and only 2 or 3 inches under full shade (*35*). Seedlings usually average between 1 and 2 inches in height by the end of the first growing season. Dominant white pine seedlings growing in the open require about 8 years to reach a height of 4.5 feet on excellent sites and about 16 years on poor sites. By the time trees are 20 years old they grow at a rate of 2 to 3 feet a year on excellent sites and from ¾ to 1½ feet on poor sites.

The period between establishment and about 30 years of age is critical in the life of stands of the western white pine type. During this period, dominance and composition of the stand are determined. Also, during this early period weeding and pruning can greatly improve both quantity and quality of western white pine growth (*11*, *21*, *37*, *38*, *42*, *68*).

The following phenological occurrences are for white pine in the Inland Empire (*8*, *16*) : Diameter growth begins about May 1, and leader growth usually begins during the first week in May. Leaf buds usually open between May 15 and the first week in June. Leader growth stops between mid-July and the first week in August. Diameter growth essentially ends about the last of August. Old needles usually turn a straw yellow between the middle of August and the first week in September and drop soon thereafter. Needle retention is usually for 3 to 4 years.

Vegetative reproduction.—Western white pine does not naturally reproduce itself by sprouting or layering. In fact western white pine cuttings are extremely difficult to root. In one study (*9*), only 2 cuttings rooted, both from trees less than 5 years old, out of more than 8,000. Limited success was attained in rooting western white pine cuttings from trees less than 15 years old.[5] In the only instance of success in rooting cuttings from older

[5] Communication from the late C. W. Waters, Montana State University, Missoula.

trees 6 percent of the untreated cuttings from a 56-year-old vigorous tree rooted (*22*).

Western white pine can be grafted readily on rootstocks of the same species (*9, 57*). Successful unions were made of western white pine scions on stocks of ponderosa pine, lodgepole pine, lodgepole pine × jack pine (hybrid), Douglas-fir, and Engelmann spruce (*6*). However, none of these grafts survived more than 2 years. Western white pine scions were grafted successfully on sugar pine rootstocks at Placerville, Calif.,[6] and on eastern white pine and hybrid (western white pine × eastern white pine) rootstocks in northern Idaho.

Sapling Stage to Maturity

Growth and yield.—Western white pine is long lived. Large white pines are often 300 to 400 years old, and occasional trees are 400 to 500 years old. The oldest white pine on record is in British Columbia; it measures 54 inches d.b.h. and is 615 years old.[7]

A white pine 84 inches d.b.h. was reported in 1933 growing in the Clearwater River region of northern Idaho (*55*). A white pine logged in the Kaniksu National Forest of Idaho yielded fifteen 16-foot logs (*55*). The present record white pine tree also growing in the Clearwater River region is 81 inches d.b.h. and 219 feet tall (*2*).

Tables 1 and 2 show the sizes, net volume, and growth rates for western white pine growing in fully stocked stands in the Inland Empire at 120 years old (*34*).

TABLE 1.—*The average size and volume of dominant and codominant western white pine growing in fully stocked 120-year-old stands in the Inland Empire*

Site Index[1]	Average dominant and codominant tree			Net volume per acre by—	
	Diameter breast high	Height	Cubic volume	Cubic measure	Scribner rule
	Inches	*Feet*	*Cubic feet*	*Cubic feet*[2]	*Board feet*[3]
40	11. 6	88	27. 5	9, 980	33, 100
60	16. 5	132	77. 0	13, 950	68, 700
80	22. 4	175	171. 7	18, 100	99, 400

[1] Based on height at 50 years.
[2] In trees 0.6 inch d.b.h. and larger.
[3] In trees 7.6 inches d.b.h. and larger.

F–199210

A large western white pine on the Clearwater National Forest, Idaho.

TABLE 2.—*Mean annual net increment per acre of fully stocked stands of western white pine in the Inland Empire*[1]

Age (years)	Mean annual net increment per acre, by site index—					
	40	60	80	40	60	80
	Cubic feet	*Cubic feet*	*Cubic feet*	*Board feet*	*Board feet*	*Board feet*
20	12	20	27	0	0	0
40	47	66	85	1	42	155
60	70	98	127	48	218	495
80	81	112	147	141	410	728
100	84	118	154	226	535	825
120	83	116	151	276	572	828
140	79	110	142	281	554	------

[1] Based on height at 50 years. Cubic volume, trees 0.6 inch d.b.h. and larger. Scribner rule, trees 7.6 inches d.b.h. and larger.

Reaction to competition.—Western white pine usually is rated as intermediate in tolerance when compared with its associates (*4, 36*). It is more tolerant than western larch and lodgepole pine,

[6] Communication from J. W. Duffield, Greeley Nursery, Olympia, Wash.

[7] Communication from E. H. Garman, British Columbia Forest Service.

about equal in tolerance to the interior variety of Douglas-fir, and less tolerant than Englemann spruce, grand fir, western hemlock, and western redcedar (*36*). Because western white pine always grows in association with more tolerant species, it is always a subclimax species (*17*, *36*).

Western white pine reproduction can become established under canopies that permit only 30 to 40 percent of full sunlight to penetrate beneath, and will persist for many years. However, growth under these conditions is slow and less than that of some of its more tolerant associates. These tolerant species will eventually overtop white pine and finally by suppression will eliminate it from the reproduction stand. If the overhead shade is removed before white pine is suppressed, it will respond to release (*68*, *69*).

White pine is only intermediate in response to thinning (*28*, *29*, *30*) because of its slowness in developing new crown and roots following release. It shows greater diameter growth response to thinning than such less tolerant associate as western larch and lodgepole pine, but it shows much less response than the more tolerant grand fir, western hemlock, or western redcedar.

Western white pine readily expresses dominance, usually by 30 years old in stands of the western white pine type (*67*).

Western white pine does not prune itself well, even in the dense stands (*58*).

Principal enemies.—Fire has left its mark at some time or other on practically every acre of western white pine forests. Western white pine is a fire species and owes its very existence to catastrophes, mainly fires, which have destroyed stands and allowed white pine to become established again (*36*). Among its associates, western white pine is rated intermediate in fire resistance (*27*).

The most serious disease of western white pine is white pine blister rust, caused by the fungus *Cronartium ribicola*. This introduced disease seriously affects the management of the species and is increasingly limiting its distribution. However, blister rust can be controlled (*50*, *52*, *53*) and research is well along in developing a blister rust resistant western white pine (*10*).

White pine pole blight also has made serious inroads into white pine stands more than 30 years old (*31*, *32*, *48*, *49*, *64*). The cause and control of this disease are unknown. At present pole blight does not seem to be spreading to new stands and has run its course in many affected stands.

Other common diseases of western white pine are those causing root and heartwood rots. Of the fungi causing root rot, the honey mushroom fungus *Armillaria mellea* is the most important (*51*); the feather-rot fungus *Poria subacida* and the pine root fungus *Fomes annosus* also cause serious damage (*41*). Western white pine in western Washington is reported to be resistant to *P. weirii* in areas where Douglas-fir has succumbed to this root rot (*1*). Major causes of heartwood rot are the ring scale fungus *F. pini* and the velvet top fungus *Polyporus schweinitzii*. Average cull in the Inland Empire, measured in board feet, is about 3 percent in western white pine stands 81 to 100 years old and about 20 percent in stands 181 to 200 years old (*3*).

Although western white pine is attacked by many insects, the mountain pine beetle (*Dendroctonus monticolae*) is most serious (*36*). Young thrifty trees are fairly resistant, but in older stands this beetle exacts an annual toll (*23*, *36*).

Animals usually do not seriously damage white pine. Porcupines and tree squirrels occasionally cause barking and girdling. Bear clawing is a frequent and widespread cause of basal scarring of western white pine trees (*51*).

RACES AND HYBRIDS

Variation in western white pine has received relatively little study. There is evidence for local variation with respect to growth in northern Idaho (*62*). Progenies from trees on the better sites grew faster on good sites than did progenies from trees from poor sites. Also progenies from high elevation trees grew faster at high elevation than did those from low elevation trees.

Hybrids have been created between western white pine and *Pinus ayacahuite*, *P. parviflora*, *P. peuce*, *P. griffithii*, and *P. strobus* (*70*).

Selections among trees with some resistance to white pine blister rust and subsequent intraspecific hybridization gives promise of the development of a blister rust resistant strain (*9*).

Revised from "Silvics of Western White Pine," by Charles A. Wellner. U.S. Forest Serv. Intermountain Forest and Range Expt. Sta. Misc. Pub. 26, 24 pp. 1962.

LITERATURE CITED

(1) Allen, John W.
1959. White pine in western Washington. Jour. Forestry 57: 573–576.

(2) American Forestry Association.
1956. These are the champs. Part II. Amer. Forests 62: 33–40.

(3) Anderson, I. V.
1934. Breakage losses and cull percent of timber in the Inland Empire. U.S. Forest Serv. Northern Rocky Mountain Forest and Range Expt. Sta. Appl. Forestry Note 63, 3 pp.

(4) Baker, Frederick S.
1949. A revised tolerance table. Jour. Forestry 47: 179–181.

(5) Barnes, Burton V., Bingham, R. T., and Schenk, John A.
1962. Insect-caused loss to western white pine cones. U.S. Forest Serv. Intermountain Forest and Range Expt. Sta. Res. Note 102, 7 pp.
(6) Bingham, R. T.
1953. Development of rust resistant white pine. U.S. Dept. Agr. Bur. Ent. and Plant Quar. Northwest Proj. Blister Rust Control Ann. Rpt. 1953: 69–73.
(7) ——— and Squillace, A. E.
1955. Self-compatibility and effects of self-fertility in western white pine. Forest Sci. 1: 121–129.
(8) ——— and Squillace, A. E.
1957. Phenology and other features of the flowering of pines, with special reference to *Pinus monticola* Dougl. U.S. Forest Serv. Intermountain Forest and Range Expt. Sta. Res. Paper 53, 26 pp.
(9) ———, Squillace, A. E., and Duffield, J. W.
1953. Breeding blister-rust resistant western white pine. Jour. Forestry 51: 163–168.
(10) ———, Squillace, A. E., and Wright, J. W.
1960. Breeding blister rust resistant western white pine. II. First results of progeny tests including preliminary estimates of heritability and rate of improvement. Silvae Genet. 9: 33–41.
(11) Boyd, Raymond J.
1959. Cleaning to favor western white pine—its effects upon composition, growth, and potential values. Jour. Forestry 57: 333–336.
(12) Copeland, Otis L., Jr.
1956. Preliminary soil-site studies in the western white pine type. U.S. Forest Serv. Intermountain Forest and Range Expt. Sta. Res. Note 33, 4 pp.
(13) ———
1958. Soil-site index studies of western white pine in the northern Rocky Mountain region. Soil Sci. Soc. Amer. Proc. 22: 268–269.
(14) Daubenmire, R. F.
1943. Soil temperature versus drought as a factor determining lower altitudinal limits of trees in the Rocky Mountains. Bot. Gaz. 105: 1–13.
(15) ———
1943. Vegetational zonation in the Rocky Mountains. Bot. Rev. 9: 325–393.
(16) ———
1949. Relation of temperature and day-length to the inception of tree growth in spring. Bot. Gaz. 110: 464–475.
(17) ———
1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecol. Monog. 22: 301–330.
(18) Daubenmire, R. F.
1953. Nutrient content of leaf litter of trees. Ecology 34: 786–793.
(19) ———
1955. Xylem layers of trees as related to weather and altitude in the northern Rocky Mountains. Ecology 36: 456–463.
(20) ———
1956. Climate as a determinant of vegetation distribution in eastern Washington and northern Idaho. Ecol. Monog. 26: 131–154.
(21) Davis, Kenneth P.
1942. Economic management of western white pine forests. U.S. Dept. Agr. Tech. Bul. 830, 78 pp.
(22) Deuber, C. G.
1942. The vegetative propagtion of eastern white pine and other five-needled pines. Arnold Arboretum Jour. 23: 199–215.
(23) Evenden, James C., Bedard, W. D., and Struble, G. R.
1943. The mountain pine beetle, an important enemy of western pines. U.S. Dept. Agr. Cir. 664, 25 pp.
(24) Ferrell, William K.
1951. Preliminary report on some forest soils of the western white pine region of Idaho. Northwest Sci. 25: 113–120.
(25) ———
1955. The relationship of pole blight of western white pine to edaphic and other site factors. Idaho Univ. Forest, Wildlife, and Range Expt. Sta. Res. Note 13, 7 pp.
(26) Fisher, George M.
1935. Comparative germination of trees species on various kinds of surface-soil material in the western white pine type. Ecology 16: 606–611.
(27) Flint, Howard R.
1925. Fire resistance of northern Rocky Mountain conifers. Idaho Forester 7: 7–10, 41–43.
(28) Foiles, Marvin W.
1955. Thinning from below in a 60-year-old western white pine stand. U.S. Forest Serv. Intermountain Forest and Range Expt. Sta. Res. Note 19, 6 pp.
(29) ———
1956. Effects of thinning a 55-year-old western white pine stand. Jour. Forestry 54: 130–132.
(30) ———
1961. Effects of thinning seed spots on growth of three conifers in the Inland Empire. Jour. Forestry 59: 501–503.
(31) Graham, Donald P.
1958. Results of some silvicultural tests in pole blight diseased white pine stands. Jour. Forestry 56: 284–287.
(32) ———
1958. Results of pole blight damage surveys in the western white pine type. Jour. Forestry 56: 652–655.

(33) Haig, I. T.
1932. Premature germination of forest tree seed during natural storage in duff. Ecology 13: 311–312.

(34) ———
1932. Second-growth yield, stand, and volume tables for the western white pine type. U.S. Dept. Agr. Tech. Bul. 323, 68 pp.

(35) ———
1936. Factors controlling initial establishment of western white pine and associated species. Yale Univ., Forestry School Bul. 41, 149 pp.

(36) ———, David, Kenneth P., and Weidman, Robert H.
1941. Natural regeneration in the western white pine type. U.S. Dept. Agr. Tech. Bul. 767, 99 pp.

(37) Helmers, Austin E.
1946. Pruning wound healing on western white and ponderosa pines. U.S. Forest Serv. North. Rocky Mountain Forest and Range Expt. Sta. Res. Note 45, 6 pp.

(38) ———
1946. Effect of pruning on growth of western white pine. Jour. Forestry 44: 673–676.

(39) Hofmann, J. V.
1917. Natural reproduction from seed stored in the forest floor. Jour. Agr. Res. 11: 1–26.

(40) Huberman, M. A.
1935. The role of western white pine in forest succession in northern Idaho. Ecology 16: 137–151.

(41) Hubert, Ernest E.
1950. Rootrots of the western white pine type. Northwest Sci. 24: 5–17.

(42) Huey, Ben M.
1950. The profit in pruning western white and ponderosa pine. U.S. Forest Serv. North. Rocky Mountain Forest Range Expt. Sta. Res. Note 85, 6 pp.

(43) Hutchison, S. Blair.
1948. Comparative marketability of pine and mixed species in the Inland Empire. U.S. Forest Serv. North. Rocky Mountain Forest and Range Expt. Sta. Res. Note 64, 4 pp.

(44) Isaac, Leo A.
1930. Seed flight in the Douglas-fir region. Jour. Forestry 28: 492–499.

(45) Larsen, J. A.
1922. Some characteristics of seeds of coniferous trees from the Pacific Northwest. Natl. Nurseryman 30: 246–249.

(46) ———
1925. Methods for stimulating germination of western white pine seed. Jour. Agr. Res. 31: 889–909.

(47) ———
1930. Forest types of the northern Rocky Mountains and their climatic controls. Ecology 11: 631–672.

(48) Leaphart, Charles D.
1958. Pole blight—how it may influence western white pine management in light of current knowledge. Jour. Forestry 56: 746–751.

(49) ——— and Copeland, Otis L., Jr.
1957. Root and soil relationships associated with the pole blight disease of western white pine. Soil Sci. Soc. Amer. Proc. 21: 551–554.

(50) Mathews, Donald N., and Hutchison, S. Blair.
1948. Development of a blister rust control policy for the national forests in the Inland Empire. U.S. Forest Serv. North. Rocky Mountain Forest and Range Expt. Sta., Sta. Paper 16, 116 pp.

(51) Molnar, A. C., and McMinn, R. G.
1960. The origin of basal scars in British Columbia interior white pine type. Forestry Chron. 36: 50–62.

(52) Moss, Virgil D.
1961. Antibiotics for control of blister rust on western white pine. Forest Sci. 7: 380–396.

(53) ——— and Wellner, Charles A.
1953. Aiding blister rust control by silvicultural measures in the western white pine type. U.S. Dept. Agr. Cir. 919, 32 pp.

(54) Olson, D. S.
1932. Seed release from western white pine and ponderosa pine cones. Jour. Forestry 30: 748–749.

(55) Otter, Floyd L.
1933. Idaho's record trees. Idaho Forester 15: 37–39.

(56) Piper, C. V.
1906. Flora of the State of Washington. U.S. Natl. Mus. Contrib. U.S. Natl. Herbarium II, 37 pp.

(57) Porter, W. A.
1954 Testing for resistance to the blister rust disease of western white pine in British Columbia. Canad. Dept Agr., Forest Biol. Div., Sci. Serv., 12 pp.

(58) Rapraeger, E. F.
1939. Development of branches and knots in western white pine. Jour. Forestry 37: 239–245.

(59) Righter, F. I.
1939. Early flower production among the pines. Jour. Forestry 37: 935–938.

(60) Squillace, A. E.
1957. Variations in cone properties, seed yield and seed weight in western white pine when pollination is controlled. Mont. State Univ. School Forestry Bul. 5, 16 pp.

(61) ——— and Bingham, R. T.
1958. Selective fertilization in *Pinus monticola* Dougl. Silvae Genet. 7:188–196.

(62) ——— and Bingham, R. T.
1958. Localized ecotypic variation in western white pine. Forest Sci. 4: 20–34.

(63) Tarrant, Robert F., Isaac, Leo A., and Chandler, Robert F., Jr.
1951. Observations on litter fall and foliage nutrient content of some Pacific Northwest tree species. Jour. Forestry 49: 914–915.

(64) U.S. Forest Service.
1952. Pole blight, what is known about it. Pole Blight Investigation Steering Committee. North. Rocky Mountain Forest and Range Expt. Sta. Misc. Pub. 4, 17 pp.

(65) Wahlenberg, W. G.
1924. Fall sowing and delayed germination of western white pine seed. Jour. Agr. Res. 28: 1127–1131.

(66) ———
1924. Circumventing delayed germination in the nursery. Jour. Forestry 22: 574–575.

(67) Watt, Richard F.
1960. Second-growth western white pine stands. U.S. Dept. Agr. Tech. Bul. 1226, 60 pp.

(68) Wellner, C. A.
1946. Improving composition in young western white pine stands. U.S. Forest Serv. North. Rocky Mountain Forest and Range Expt. Sta. Res. Note 43, 6 pp.

(69) ——— and Foiles, M. W.
1951. What to see and where to find it on the Deception Creek Experimental Forest. U.S. Forest Serv. North. Rocky Mountain Forest and Range Expt. Sta. Misc. Pub. 2, 72 pp.

(70) Wright, Jonathan W.
1959. Species hybridization in the white pines. Forest Sci. 5: 210–222.

(71) Zon, R.
1915. Seed production of western white pine. U.S. Dept. Agr. Bul. 210, 15 pp.